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Barrett,
S.W.

A fire regimes database for coniferous forests in the inland northwest

A FIRE REGIMES DATABASE FOR CONIFEROUS FORESTS IN THE INLAND NORTHWEST

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Stephen W. Barrett[1]

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[1]Research Forester with Systems for Environmental Management, Missoula, MT. Final report submitted in fulfillment of Research Joint Venture Agreement INT-92676-RJVA between S.E.M. and USDA Forest Service Intermountain Research Station.

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INTRODUCTION

This document represents the final report for Part II of Research Joint Venture Agreement INT-92676-RJVA between USDA Forest Service and Systems for Environmental Management[2]. The goal of this portion of the project was to develop a fire regimes database based on fire history studies in the greater Columbia River Basin (CRB) east of the Cascade Crest. Previous databases and classifications (Heinselman 1978, Kilgore 1978, Kilgore 1985, Agee 1993, Agee 1994, Heyerdahl et al. 1994, Brown [in prep.], Morgan et al. [in prep.]) often focus on general findings from fire history studies. By comparison, this database contains highly detailed site- and stand-specific variables, which would be potentially useful for developing a comprehensive fire regimes classification for coniferous forests in the study area.

OBJECTIVES

Specific objectives were to:

1. conduct a literature search for all published and unpublished fire history studies in the Inland Northwest.

2. for each study site, extract or interpolate data on forest cover- and habitat type; geographic variables such as landform, slope, and aspect; and fire history variables, such as mean fire interval and fire severity pattern.

3. create a relational database for a post-RJVA analysis.

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[2] Part I, "Coarse Scale Fire History in Relation to Macroclimatic Precipitation in the Columbia River Basin, ca.1540 to 1940", is on file at USDA Forest Service Intermountain Research Station, Intermountain Fire Sciences Laboratory, Missoula, MT.

METHODS

Literature Review. A library search was conducted to obtain copies of all published fire history studies for in the Interior Northwest. Also, ecologists throughout the region were contacted to acquire reports or data for any unpublished fire history work. Site information was obtained by extracting data directly from the reports (e.g., from tables and figures), by interpolating data based on this author's extensive experience in analyzing fire history, and by extrapolating information from other sources as area vegetation classifications, topographic maps, and National Weather Service reports. Data re-interpretation occasionally was necessary if studies were judged to be of somewhat questionnable quality. For example, portions of many reports lacked sufficient detail to enable extraction of desired classes of data. When a report presented fire regimes data for other than individual small stands (Arno and Peterson 1983), the data were re-analyzed from that perspective. And when reports yielded high quality fire regimes data but contained only ambiguous information on stand variability, a representative range of stand conditions was modelled by consulting vegetation classifications, topographic maps, and other pertinent sources of information. Note, however, that fire regimes data were not extrapolated between the various studies, because the primary objective was to obtain site-specific fire history information.

The following classes of data were defined for the database:

1. **Author/Date**: Study author(s) and year of study completion.
2. **Site Name**: Narrative location of study area.
3. **Region**: Northern Rockies, Blue Mountains, North Cascades (here defined as north of

the Columbia River), Central Cascades (44 degrees latitude to the Columbia River), Southern Cascades (California to 44 degrees latitude).

4. **State/Canadian Province**: Montana, Idaho, Wyoming, Washington, Oregon, California, Alberta, British Columbia.
5. **Latitude/Longitude**: In degrees and minutes; for large study areas, a central location was selected if more-specific data on site locations were not available.
6. **Area Surface Form**. The following unpublished system of landform classes (pers. comm. with Professor J. Crowley, Dept. Geography, Univ. Montana, Missoula) was used to characterize the land surrounding each study site: Smooth Plain, Irregular Plain, Rough Plain, Plateau, Hills/Narrow Valleys, Open Hills, Mountains/Narrow Valleys, Mountains/Broad Valleys, Plateau-like Mountains, Plains with Mountains.
7. **Land Dissection**. A subjective rating was used to describe land dissection within a given study area. For example, unless the report or topographic maps indicated otherwise, stands occupying slopes of less than 10 percent steepness were assigned to the "Lightly" dissected class, "Moderately" dissected generally was assigned when stands occupied slopes between 11 and 75 percent steepness, and "Highly" dissected generally was used when stands occupied slopes greater than than 75 percent steepness.
8. **Forest Cover Type**. Society of American Foresters (1980) (SAF) Index of Forest Cover Types was used to characterize the dominant forest cover type for each sample stand (i.e., actual sample stands or modeled stands based on data

interpretation).

9. **Forest Habitat Type**. Applicable forest vegetation classifications were used to characterize potential climax vegetation (i.e., series/association) for each sample stand.

10. **Overstory**. The overstory layer within each sample stand was characterized according to one of the following 4 overstory descriptors, used to depict typical stand conditions under the prevailing fire regime: immature, mature, overmature, mixed overstory.

11. **Age Structure**. Stand age class structure also was defined: primarily even aged (i.e., containing one or more fire-regenerated seral age classes), or primarily unevenaged.

12. **Number of Age Classes**. The number of seral age classes per sample stand was listed ("0" was used to represent primarily unevenaged stands).

13. **Topographic Position**. Four classes were used to described stand topographic position, modified from Pfister et al. (1977): low to mid slope, mid to upper slope, bench/flat, riparian.

14. **Elevation (ft.)**. A minimum and maximum elevational range was obtained for each sample stand, either directly from the written report or from topographic maps.

15. **Slope Steepness**. The following slope classes were used to describe slope steepness of sample stands: flat to 10 percent, 10 to 40 percent, 40 to 75 percent, and greater than 75 percent. When this information was not contained in the original reports, slope class was estimated from topographic maps (Rothermel 1983).

16. **Aspect**. Two nominal classes were used to describe aspect position: "northerly" and "southerly" (i.e., relative to the 90 degree- and 270 degree ordinal benchmarks).

17. **Mean Fire Interval (MFI)**. Data were entered for presettlement MFIs (Romme 1980) at the small stand level of analysis (Arno and Peterson 1983); this information was extracted directly from the reports or was estimated after data re-analysis.

18. **Fire Severity Pattern**. Three fire severity classes were used to describe characteristic fire severities at the stand level: nonlethal, lethal, or mixed severity (Barrett et al. 1991, Brown [in prep], Morgan et al. [in prep.]).

19. **Mean Annual Precipitation (in.)**. Estimates of mean annual precipitation for the stand level of analysis were derived from fire history reports whenever possible. However, these data usually had to be estimated from isohyetal maps or from records for any nearby National Weather Service (NWS) stations (Pacific Northwest River Basins Commission 1969, National Oceanic and Atmospheric Administration 1982), if the stations had elevations similar to those in a given study area.

20. **Nearest NWS Station**. The name of the nearest NWS station was entered, preferably those having precipitation"normals" for the period 1951 to 1980.

Database Structure. The data initially were entered into 2 database files using dBASE III Plus software (disk copies enclosed with this report). The file "AREADATA.dbf" contains all of the

discrete variables for the sample stands. These include the study area attributes (e.g., region, state, latitude/longitude), the stand elevation range, and the stand fire regime descriptors (i.e., MFI and fire severity pattern). Conversely, the file "STANDS.dbf" contains all of the potentially highly variable stand traits under a given fire regime, such as differing forest cover types, habitat types, slope steepness, aspects, and age structures. The field "PAGE" is used to link the 2 database files. For example, for study number one ("REF 1") all data under "PAGE 1" in both files correspond, all "PAGE 2" data share linkage, and so on. To enable subsequent analysis, the 2 database files then were joined to create a third file named "REGIMES.dbf" (also included with this report). Consequently, for purposes of interpretation, each file record in REGIMES.dbf represents one sample stand with a corresponding fire regime.

Following is the database file structure (see Appendix A for codes list):

AREADATA.DBF:

REF (no.).
PAGE (no.).
REGION.
STATE.
LATDEGREE (latitude, degrees).
LONGDEGREE (longitude, degrees).
LATMINUTE (latitude, minutes).
LONGMINUTE (longitude, minutes).
SURF_FORM (area surface form).
ELEV_MIN (minimum range for stand elevation, ft.).
ELEV_MAX (maximum range for stand elevation, ft.).
DISSECTION (highly, moderately, lightly).
MFI (stand mean fire interval, nearest whole yr.).
SEVERITY (stand fire severity pattern: nonlethal, lethal, mixed).
PCP_ANNUAL (for stand elevation zone, mean in.).
STATION (NWS station name).

STANDS.DBF:

REF (no.).
PAGE (no.).
SAF (dominant forest cover type [Society of American Foresters 1980]).
HABITAT (potential climax series).
TYPE (potential climax association).
OVERSTORY (immature, mature, overmature, mixed).
AGE_STRUCT (even aged or uneven age).
TOPOG (slope position).
NO_CLASSES (number of seral age classes).
SLOPE (percent).
ASPECT (northerly or southerly).

After the database was constructed, descriptive statistics were used to describe all database attributes. This analysis includes the distribution of sample stands by region and state/Canadian Province, by SAF forest cover type, by forest habitat type, by slope, aspect, and land dissection class, by fire frequency- and severity pattern, and so on.

RESULTS/DISCUSSION

Sample Locations. Following is a descriptive summary of all database components. Data were obtained from 108 fire history studies, about a third of which have been published (Appendix B). Site- and fire regimes data were obtained for 979 sample stands, that is, original sample sites or representative stands modeled after data re-analysis. Eighty-four percent of the sample stands were from the Northern Rockies, and studies in Montana and Idaho produced 77 percent of these data (figs. 1, 2). The remaining Northern Rockies data originated from Alberta (15%), northwest Wyoming (5%), and British Columbia (3%). The East Cascades provided 13 percent

of the sample stands in the database. For example, studies in west-central Washington (and southern British Columbia) produced about 60 percent of these data, whereas the remainder were derived from west-central Oregon and the Southern Cascades (i.e., south-central Oregon, northeastern California). The remaining 3 percent of the sample stands in the database were from the Blue Mountains, primarily in northeastern Oregon.

The highly skewed sample locations clearly will necessitate a substantial amount of extrapolation to less thoroughly sampled subregions. Also, statistical variation in the database conceivably could be reduced by the fact that sampling in the Northern Rockies by this author and by colleague S. F. Arno (Research Forester, USDA Forest Service Intermountain Research Station, Missoula, MT) produced nearly half of the sample stands in the database. And because most (97%) of the samples were in just 2 of the 10 area surface form classes (i.e., "Mountains with narrow valleys", "Mountains with broad valleys"; fig. 3), the utility of this class of variables seems questionable.

Stand vegetation data. Stand vegetation composition was first analyzed by SAF forest cover type (fig. 4). Seventy percent of the samples occur in 3 of the 15 sampled cover types: ponderosa pine (*Pinus ponderosa*), lodgepole pine (*Pinus contorta*), and Interior Douglas-fir (*Pseudotsuga menziesii var. glauca*). These 3 types contributed similar amounts of data, ranging from 20 to 26 percent of the total database each. Ninety-seven percent of the sample stands occur in 8 cover types--that is, the above 3 cover types plus western larch (*Larix occidentalis*), spruce-fir (*Picea engelmannii-Abies lasiocarpa*), whitebark pine (*Pinus albicaulis*), western redcedar-western hemlock (*Thuja plicata-Tsuga heterophylla*), and aspen (*Populus tremuloides*),

in descending order of prevalence. (Results for redcedar- or western hemlock dominated stands [i.e., SAF #228, 224] are combined here because the stands apparently are similar ecologically [Pfister et al. 1977, Cooper et al. 1983], the species often co-dominate stands [i.e., SAF type #227], and, moreover, there are few fire history studies for each type alone).

The distribution of sample stands by forest habitat type also is highly skewed. For example, data were obtained for 17 potential climax series (fig. 5), but 6 series provided 92 percent of the stands: Douglas-fir (37%), subalpine fir (32%), grand fir (*Abies grandis*)(12%), western redcedar (5%), ponderosa pine (3%), and whitebark pine (3%). The other 11 series each contributed less than one percent of the sample stands in the database: lodgepole pine, limber pine (*Pinus flexilis*), Engelmann spruce, white spruce (*Picea glauca*), western hemlock, mountain hemlock (*Tsuga mertensiana*), alpine larch (*Larix lyallii*), western juniper (*Juniperus occidentalis*), white fir (*Abies concolor*), red fir (*Abies magnifica*), and incense cedar (*Libocedrus decurrens*). (The latter 3 series are limited to the southwestern margin of the CRB, whereas white spruce occurs primarily north of the CRB, in Canada).

The distribution of stands among 109 sampled habitat type associations also is highly skewed (figs. 6-11, Appendix C). For example, nearly 70 percent of the 361 stands in the Douglas-fir series occur in just 3 of 23 sampled habitat types (fig. 6): common snowberry (*Symphoricarpos albus*), pinegrass (*Calamagrostis rubescens*), and ninebark (*Physocarpus malvaceus*)(Pfister et al. 1977). These 3 major types each contributed 18 to 26 percent of the stands in the Douglas-fir series, moreover, together they comprise nearly 25 percent of all stands in the database. About 10 percent of the stands in the Douglas-fir series were on highly xeric sites, such as Douglas-fir/Idaho fescue (*Festuca idahoensis*) and /bluebunch wheatgrass

(*Agropyron spicatum*)(Pfister et al. 1977). Relatively few old growth stands remain along these typically heavily logged, valley edges, perhaps contributing to the paucity of data for such sites. About a third of the stands in the Douglas-fir series were in 7 moderately moist habitat types (Pfister et al. 1977, Steele et al. 1983) such as: Douglas-fir/ninebark, /dwarf huckleberry (*Vaccinium caespitosum*), /blue huckleberry (*V. globulare*), and /mountain sweetroot (*Osmorhiza chilensis*).

Most (64%) of the stands in the subalpine fir series (fig. 7) occur in just 3 of 20 sampled habitat types (Pfister et al. 1977): grouse whortleberry (*V. scoparium*), beargrass (*Xerophyllum tenax*), and queencup beadlily (*Clintonia uniflora*)(these samples total 20 percent of all stands in the database). About 60 percent of the 308 stands in the subalpine fir series were in the lower subalpine zone, about 40 percent were in the upper subalpine, and less than one percent were near upper timberline.

In summary of the 2 most prevalent potential climax series in the literature review, nearly 70 percent of the 979 fire history sample stands are in the Douglas-fir and subalpine fir potential climax series. Furthermore, nearly half the sample stands in the database occur in just 6 habitat types within those 2 series (i.e., just 5% of the 109 sampled habitat types).

Data also were obtained for 119 sample stands distributed among 18 habitat types in the grand fir series (fig. 8). These data were roughly equally distributed between relatively moist habitat types (Cooper et al. 1987), such as grand fir/clintonia, /twinflower (*Linnaea borealis*), /blue huckleberry, and /wild ginger (*Asarum caudatum*), and relatively dry types (Steele et al. 1981, Williams and Smith 1991) such as grand fir/ninebark, /pinegrass, /Cascade Oregon grape (*Berberis nervosa*), /white spirea (*Spirea betulifolia*), and /mountain maple (*Acer glabrum*).

The data for potential climax series and individual habitat types become progressively more sparse for remaining 20 percent of the database (N=191 stands). For example, only 49 sample stands occur in the western redcedar series (fig. 9). About 90 percent of those stands occur in 3 of 6 sampled habitat types (Cooper et al. 1987), primarily on moderately moist- to moist sites: redcedar/queencup beadlily, /lady-fern (*Athyrium filix-femina*), and /wild ginger (*Asarum caudatum*). Conversely, the database contains data for 28 sample stands on highly xeric sites in the ponderosa pine series (fig. 10): primarily ponderosa pine/bitterbrush (*Purshia tridentata*), /Idaho fescue, and /bluebunch wheatgrass habitat types (Pfister et al. 1977). Data were obtained for 26 sample stands in the whitebark pine series (fig. 11)(Pfister et al. 1977), 62 percent of which occur on relatively dry upper subalpine sites (i.e., /grouse whortleberry h.t.). Thirty-eight percent of the stands in the whitebark pine series occur on relatively moist sites in the lower subalpine zone (e.g., subalpine fir-whitebark pine/grouse whortleberry h.t.). (The remaining 9 percent of the sample stands in the database [N=88] are widely distributed among 11 series and 34 habitat types [Appendix C]).

Three categories were used to describe stand physical structure. First, the 979 sample stands are roughly evenly distributed between primarily even-age stands (55%), versus stands that are primarily uneven-age (45%)(fig. 12). In terms of the number of seral age classes per stand (fig. 13), 42 percent of the sample stands were single-aged, 20 percent had 2 seral age classes, 9 percent had 3 or more seral classes, and the remaining 29 percent of the sample stands had no readily identifiable seral age classes (i.e., uneven-age structure). (Note: figures 12 and 13 show different values for uneven-age stands, because some primarily uneven-age stands also contain seral age classes). Finally, the database contains information on the types of stand

overstory structures that prevailed under various fire regimes (fig. 14). Most stands (93%) had either mixed-age or overmature overstories, whereas only 7 percent of the sample stands experienced fires during the immature- or mature stages of development.

Stand terrain- and precipitation data. The database contains the following categories of information for stand terrain- and precipitation variables. Among the 4 classes that were defined for stand topography (fig. 15), 91 percent of the sample stands occur in either low- to mid-slope or mid- to upper slope terrain--with approximately equal numbers of stands occurring in each class. Only 8 percent occur in the "bench/flat" class, and only 10 sample stands are in riparian zones. In terms of distribution by land dissection class (fig. 16), nearly three-quarters of the stands occur in areas considered to be "moderately" dissected, followed by lightly dissected (25%), and highly dissected (2%). Nearly 60 percent of the sample stands had primarily southerly aspects, whereas 39 percent were on northerly aspects, and only 3 percent of the stands occur on flat terrain (fig. 17). In fact, most of the sample stands occupy gently sloped- to moderately steep terrain (fig. 18). For example, nearly half occupy the 10 to 39 percent slope class, 40 percent of the stands occur in the 40 to 74 percent slope class, 14 percent of the stands occupy slopes with less than 10 percent steepness, and only 5 stands occupy slopes with greater than 75 percent steepness. The data also were analyzed for stand maximum elevation range (fig. 19). Only 3 percent of the stands occur below 3000 feet elevation, and 5 percent occupy sites greater than 8000 feet. The remaining 92 percent of the sample stands are relatively well dispersed among the 5 one thousand-foot classes between 3000 and 8000 feet elevation.

Estimates also were derived for stand mean annual precipitation, here presented

according to 4 subjectively defined ranges (fig. 20). Nearly 85 percent of the stands occur in 2 precipitation classes (i.e., 15-29 in.; 30-49 in.), and these 2 classes had roughly equal numbers of stands. The remaining 14 percent of the stands had either less than 14 inches mean annual precipitation values of either less than 14 inches, or, more than 75 inches--again with approximately equal numbers of stands in each class.

Fire regimes data. Fire frequency- and severity patterns may be the 2 most important aspects of ecosystem fire regimes (Heinselman 1978, Kilgore 1978, Kilgore 1985, Agee 1993, Agee 1994, Heyerdahl et al. 1994, Brown [in prep.], Morgan et al. [in prep.]). Frequency and severity also are the most easily described, and the most frequently cited, classes of fire history data in reports. Consequently, these elements are only 2 fire regimes descriptors in the database. Three fire severity classes (Morgan et al. [in prep]) were used, and each contain roughly equal amounts of data: mixed (39%), nonlethal (31%), and lethal severity (30%). Maps of historical fire regimes in the CRB (Morgan et al. [in prep]) suggest that about 20 percent of the coniferous forests had a nonlethal fire regime during the presettlement era--primarily ponderosa pine. During the fire exclusion period, however, many previously nonlethal fire regimes may have shifted toward mixed severity (Morgan et al. [in prep.]).

Data were highly variable for the second class of fire regimes information, that is, presettlement fire frequency expressed as small-stand MFI (Arno and Peterson 1983). These data are presented according to 9 subjectively defined classes, beginning with the most frequently burned ecosystems (fig. 22). Only about 4 percent of the sample stands had MFIs of less than 10 years. However, one-quarter of all recorded MFIs were between 10 and 24 years,

and 20 percent were in the 25 to 49 year frequency class. Twelve percent of the sample stands had MFIs of between 50 and 74 years. Nine percent had MFIs of between 75 and 99 years. Eleven percent of the sample stands had average fire frequencies of between 100 and 149 years, and the 150 to 249 year frequency class contained 13 percent of all data. Finally, only 5 percent of the stand MFIs were between 250 and 349 years long, and the remaining 2 percent of the data had MFIs in excess of 350 years.

The data for fire frequency and severity also were analyzed in tandem for any obvious patternization (table 1, fig. 23). Results support the concept that lethality generally increases with increasing interval length, and that mixed severity fire intervals usually range from moderately short- to moderately long. All of the data for nonlethal fires occur in the first 4 frequency classes described above (i.e. MFI <75 yr), but nearly 75 percent of these stands had MFIs of less than 25 years in length. Mixed severity fires displayed the widest variation, and occurred in all but the shortest MFI class (i.e., MFI <9 yr). However, 80 percent of these data occurred in MFI classes spanning from 25 to 150 years long. Lethal fires also occurred in nearly every MFI class. Even so, 90 percent of the lethal MFIs ranged from 75 to 350+ years long. Data in the 2 moderately long MFI classes (i.e., spanning 75-149 yr) were nearly equally divided between mixed severity- and lethal fires, whereas lethal fires produced most (86%) of the MFIs in excess of 150 years long.

Clearly, presettlement fire regimes were highly diverse in Inland Northwest forests, at least among 4 major cover types--ponderosa pine, lodgepole pine, Douglas-fir, and western larch. The highly skewed contributions of data by these forest cover types might suggest some bias toward studying commercially valuable tree species. Coincidentally, however, the

proportions of data by cover type are roughly similar to those for each type's areal coverage of CRB forested land (Morgan et al. [in prep.]). (The grand fir cover type is a major exception, in that it occupies 9 percent of the forested land but produced less than one percent of the database samples). Based on this observation, one could argue that there is little need for further fire history studies in the Inland Northwest. On the contrary, fire's historic role and the effects of fire exclusion remain relatively poorly understood for a number of forest types, such as: grand fir, white fir, mountain hemlock, quaking aspen (*Populus tremuloides*), alpine larch, western juniper, and limber pine. Insufficient documentation of fire regimes variation exists even for well sampled forest types such as Douglas-fir and lodgepole pine. Furthermore, because the sample locations are highly skewed, some subregions wholly lack substantial databases (e.g., Blue Mountains). Even in the Northern Rockies subregion, few samples have been collected in southern- and Eastern Idaho, in portions of Western Wyoming, and along the Rocky Mountain Front. And, the mixed severity fire regime in general, which may be the predominant type in the Inland Northwest (Morgan et al. [in prep.]), is much less well understood than the nonlethal- and lethal fire regimes. Nonetheless, this is the most comprehensive database to date, and these fire history studies form a cornerstone for understanding presettlement fire ecology in the greater CRB.

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Table 1. Number and percent of sample stands in each of 3 fire severity classes in relation to 9 fire frequency classes (subtotals equal contribution to entire database).

MFI CLASS	NON LETHAL	LETHAL	MIXED	SUBTOTAL
<9 yr	34 (100%)	--	--	34 (4%)
10-24 yr	191 (79%)	6 (3%)	44 (18%)	241 (25%)
25-49 yr	70 (36%)	9 (5%)	116 (60%)	195 (20%)
50-74 yr	12 (10%)	18 (15%)	88 (75%)	118 (12%)
75-99 yr	--	36 (42%)	49 (58%)	85 (9%)
100-149 yr	--	55 (51%)	52 (49%)	107 (11%)
150-249 yr	--	109 (83%)	22 (17%)	131 (13%)
250-349 yr	--	48 (92%)	4 (8%)	52 (5%)
>350 yr	--	14 (88%)	2 (13%)	16 (2%)
SUBTOTAL:	307 (31%)	295 (30%)	377 (39%)	979 (100%)

LIST OF FIGURES

1. Distribution of 979 sample stands by 3 subregions in the greater CRB (number of stands in parentheses).

2. Sample stand distribution by state and Canadian Province (number of stands in parentheses). Codes: MT (Montana), ID (Idaho), ALTA (Alberta), WY (Wyoming), BC (British Columbia), N.CA (Northern California), OR (Oregon), WA (Washington).

3. Sample stand distribution by area surface form class (number of stands in parentheses; see Methods section for 8 unlisted "Misc." classes).

4. Sample stand distribution by SAF forest cover type (number of stands in parentheses). Codes: PP (*Pinus ponderosa*), LP (*Pinus contorta*), DF (*Pseudotsuga menziesii* var. *glauca*), WL (*Larix occidentalis*), S-F (*Picea* spp.-*Abies lasiocarpa*), WB (*Pinus albicaulis*), C-H (*Thuja plicata-Tsuga heterophylla*), ASP (*Populus tremuloides*).

"Misc." cover types for 48 stands: *Abies grandis* (14) Pinus monticola (11) *Pinus flexilis* (6) *Juniperus occidentalis* (8) *Tsuga mertensiana* (4) *Abies concolor* (2) *Abies magnifica* (3).

5. Sample stand distribution by habitat type series (number of stands in parentheses). Codes: PSME (*Pseudotsuga menziesii* var. *glauca*), ABLA (*Abies lasiocarpa*), ABGR (*Abies grandis*), THPL (*Thuja plicata*), PIPO (*Pinus ponderosa*), PIAL (*Pinus albicaulis*).

"Misc." series for 88 stands (see also APPENDIX C): PICO (*Pinus contorta*)(6) LALY (*Larix lyallii*)(10) ABCO (*Abies concolor*)(14) ABMA (*Abies magnifica*)(3) TSHE (*Tsuga heterophylla*)(14) TSME (*Tsuga mertensiana*)(8) PIEN (*Picea engelmannii*)(11) PIGL (*Picea glauca*)(7) PIFL (*Pinus flexilis*)(7) JUOC (*Juniperus occidentalis*)(6) LIDE (*Libocedrus decurrens*)(2).

6. Sample stand distribution by Interior Douglas-fir habitat type associations (number of stands in parentheses). Codes: SYAL (*Symphoricarpos albus*), CARU (*Calamagrostis rubescens*),

Fig. 6 (cont.): PHMA (*Physocarpus malvaceus*), VACA (*Vaccinium caespitosum*), AGSP (*Agropyron spicatum*), FEID (*Festuca idahoensis*), BERE (*Berberis repens*), OSCH (*Osmorhiza chilensis*),
VAGL (*Vaccinium globulare*), FESC (*Festuca scabrella*).

"Misc." PSME habitat types for 33 stands: LIBO (*Linnaea borealis)*(1) CAGE (*Carex geyeri)* (5) SPBE (*Spirea betulifolia)*(2) ARUV (*Arctostaphylos uva-ursi*) (3) JUCO (*Juniperis communis*) (4) ARCO (*Arnica cordifolia*)(1) SYOR (*Symphoricarpos oreophilus*) (3) BENE (*Berberis nervosa*) (3) HODI (*Holodiscus discolor*)(4) AGIN (*Agropyron intermedium*)(2) ACGL (*Acer glabrum*)(2) CELE (*Cercocarpus ledifolius*)(1) PUTR (*Purshia tridentata*)(2).

7. Sample stand distribution by subalpine fir habitat type associations (number of sample stands in parentheses). Additional codes: VASC (*Vaccinium scoparium*), XETE (*Xerophyllum tenax*), CLUN (*Clintonia uniflora*), MEFE (*Menziesia ferruginea*).

"Misc." ABLA habitat types for 25 stands: ARCO (3) ARLA (*Arnica latifolia*)(5) CAGE (1) LIBO (3) ALSI (*Alnus sinuata*)(1) LUHI (*Luzula hitchcockii*)(7) RIMO *(Ribes montigenum*)(1) STAM (*Streptopus amplexifolius*)(1) SPBE (1) RHAL (*Rhododendron albiflorum*)(1) VAMY (*Vaccinium myrtillus*)(1).

8. Sample stand distribution by grand fir habitat type associations (number of sample stands in parentheses). Additional code: ACTR (*Achlys triphylla*).

"Misc." ABGR habitat types for 16 stands: ARCO (1) ASCA (*Asarum caudatum*)(4) XETE (3) SYAL (2) VAMY (2) HODI (2) CAGE (1) SETR (*Senecio triangularis*)(1).

9. Sample stand distribution by western redcedar habitat type associations (number of sample stands in parentheses). Additional codes: ATFI (*Athyrium filix-femina*), OPHO (*Oplopanax horridum*), ADPE (*Adiantum pedatum*), GYDR (*Gymnocarpium dryopteris*).

10. Sample stand distribution by ponderosa pine habitat type associations (number of sample stands in parentheses).

LIST OF FIGURES (cont.)

11. Sample stand distribution by whitebark pine habitat type associations (number of sample stands in parentheses).

12. Sample stand distribution by stand age structure (number of sample stands in parentheses).

13. Sample stand distribution by number of stand seral age classes (number of sample stands in parentheses).

14. Sample stand distribution by stand overstory structure (number of sample stands in parentheses).

15. Sample stand distribution by stand topography class (number of sample stands in parentheses).

16. Sample stand distribution by land dissection class (number of sample stands in parentheses).

17. Sample stand distribution by aspect (number of sample stands in parentheses).

18. Sample stand distribution by slope class (number of sample stands in parentheses).

19. Sample stand distribution by stand maximum elevation range (number of sample stands in parentheses).

20. Sample stand distribution by mean annual precipitation class (number of sample stands in parentheses).

21. Sample stand distribution by fire severity class (number of sample stands in parentheses).

22. Sample stand distribution by fire frequency class (MFI) (number of stands in parentheses).

23. Percent of sample stands in each of 3 fire severity classes in relation to 9 fire frequency classes.

FIG. 1. SUBREGION
(N=979 Stands)

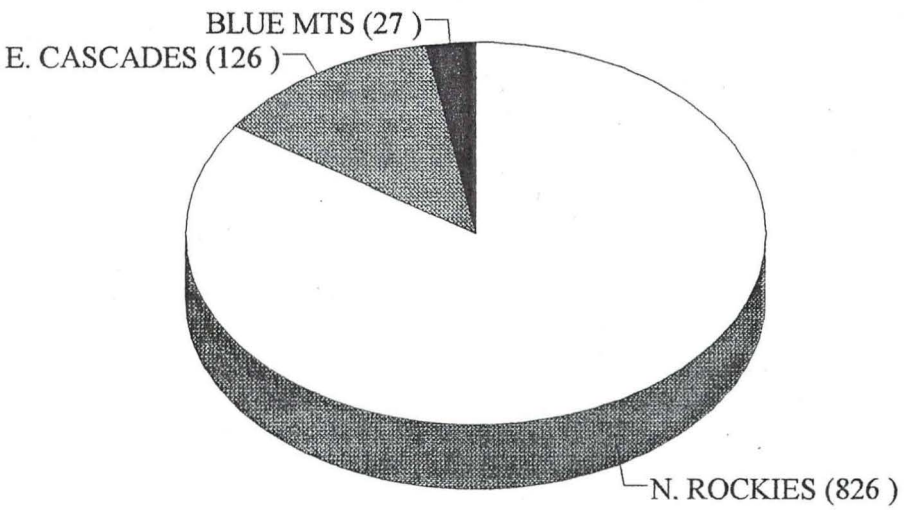


FIG. 2. STATE/PROVINCE

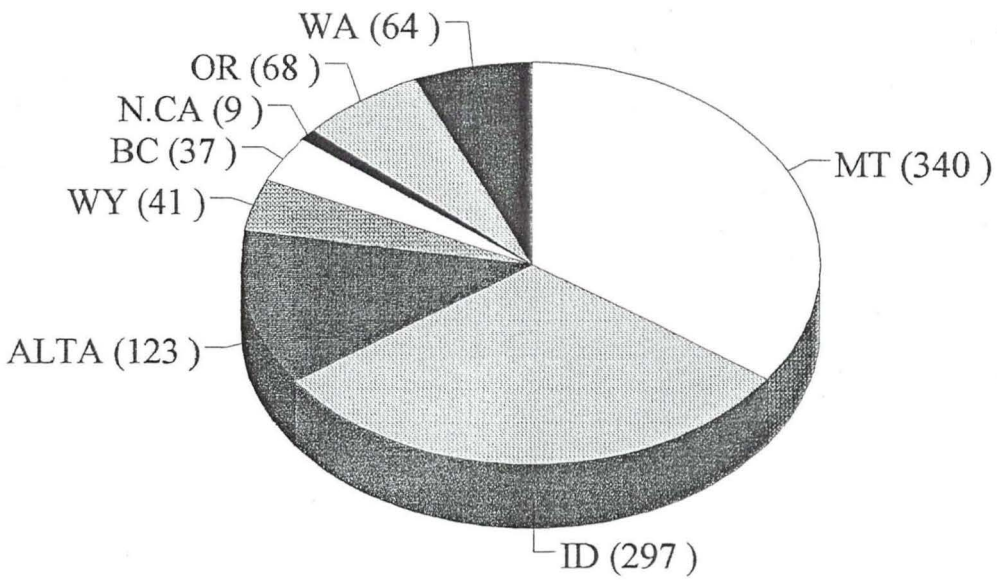


FIG. 3. AREA SURFACE FORM

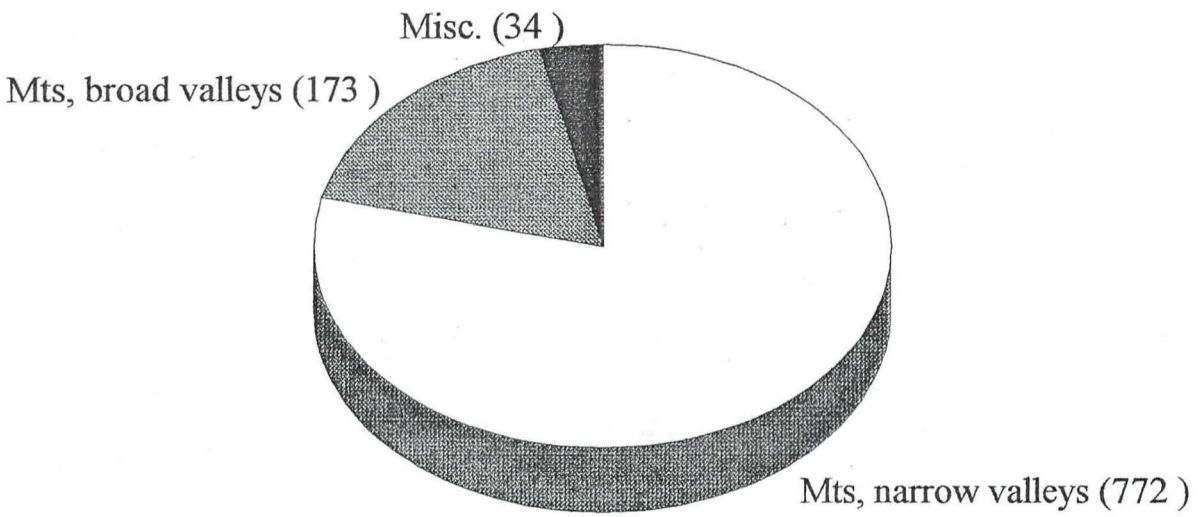


FIG. 4. FOREST COVER TYPE
(SAF 1980)

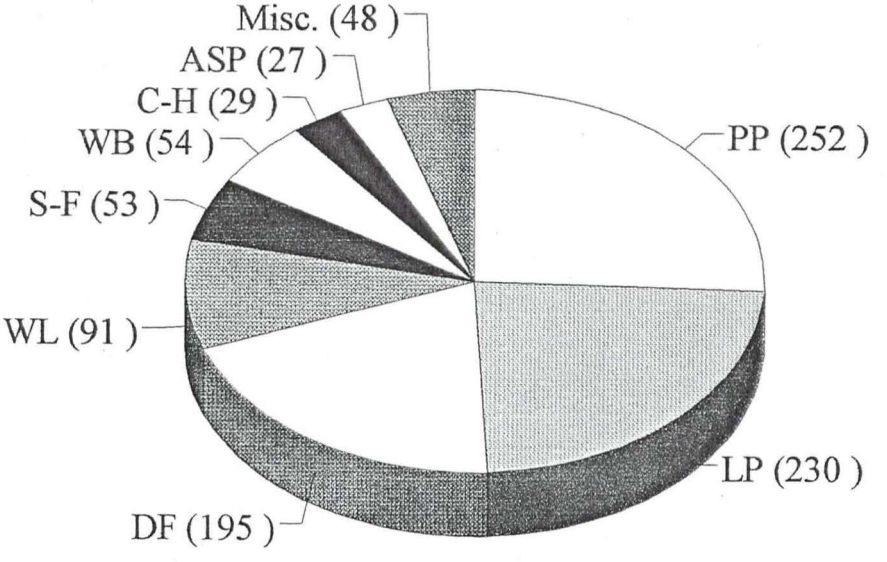


FIG. 5. HABITAT TYPE: SERIES

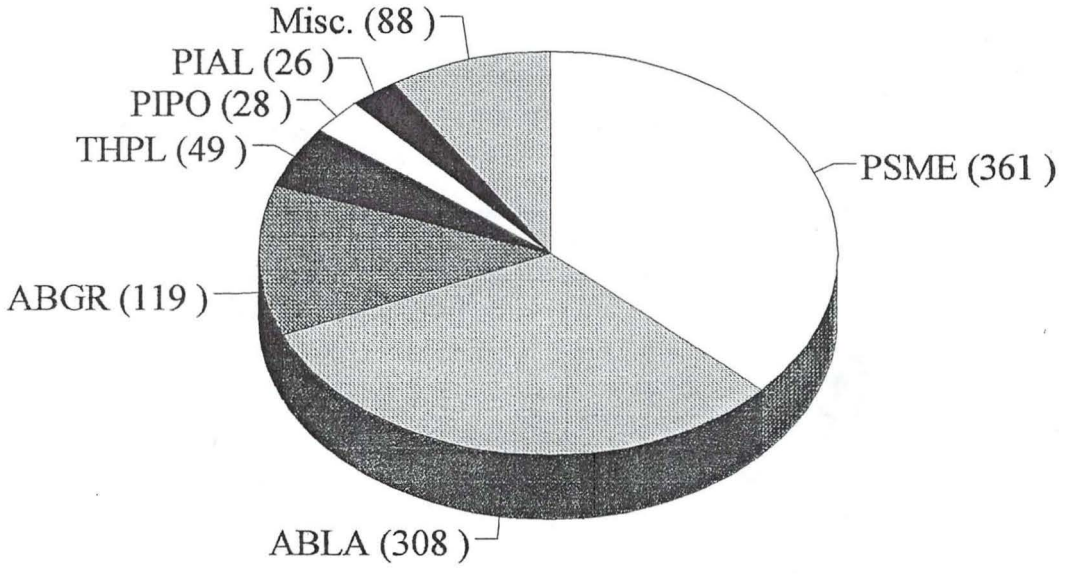


FIG. 6. DOUGLAS-FIR HABITAT TYPES
(N=361 Stands)

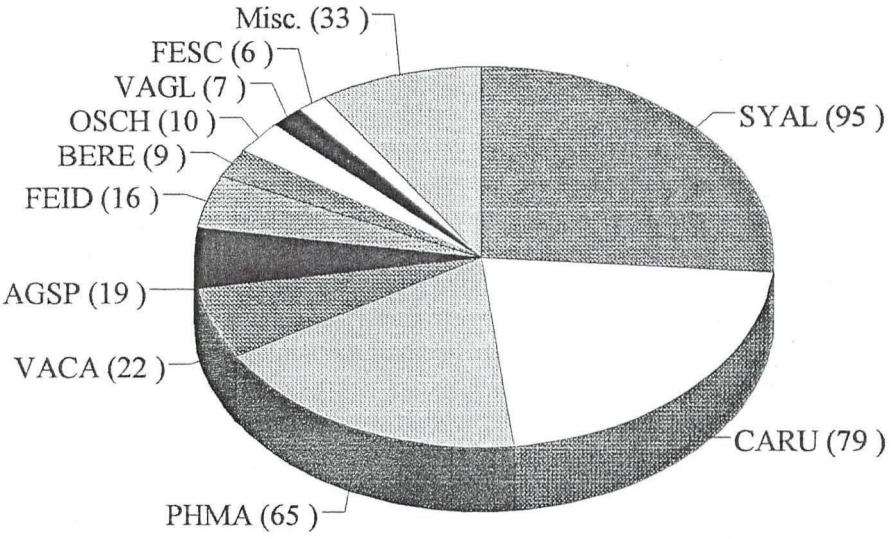


FIG. 7. SUBALPINE FIR HABITAT TYPES
(N=308 Stands)

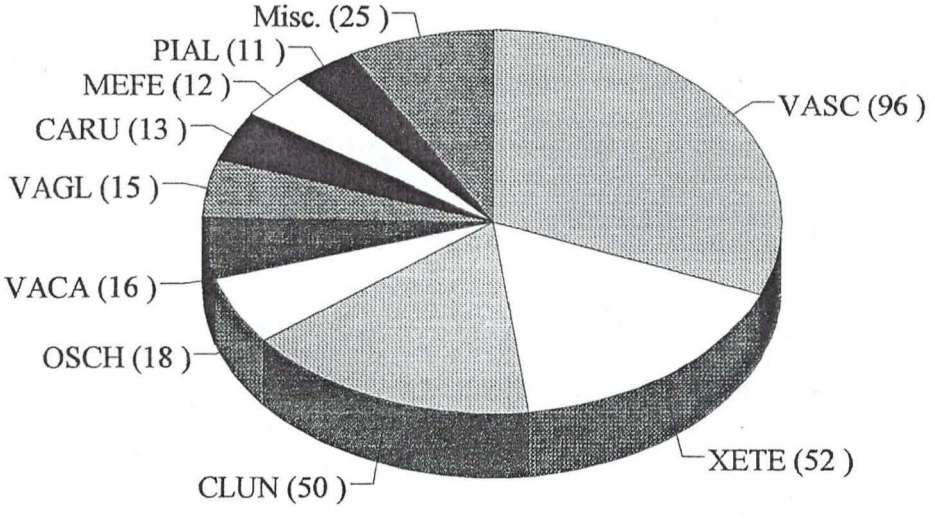


FIG. 8. GRAND FIR HABITAT TYPES
(N=119 Stands)

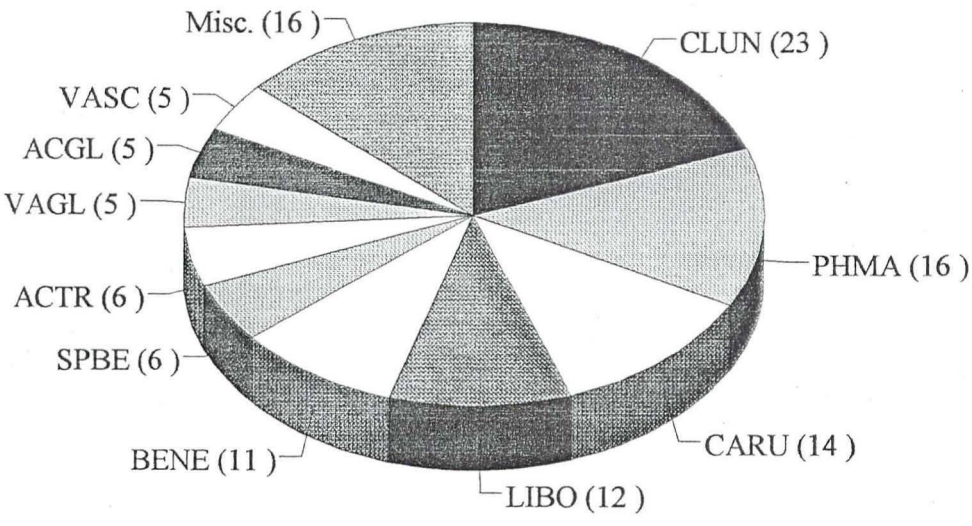


FIG. 9. REDCEDAR HABITAT TYPES
(N=49 Stands)

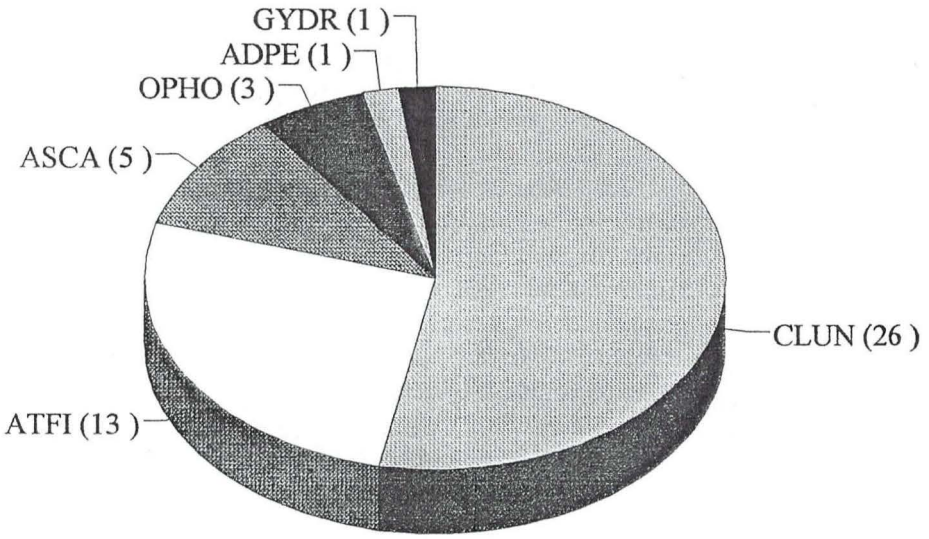


FIG.10. PONDEROSA PINE HABITAT TYPES
(N=28 Stands)

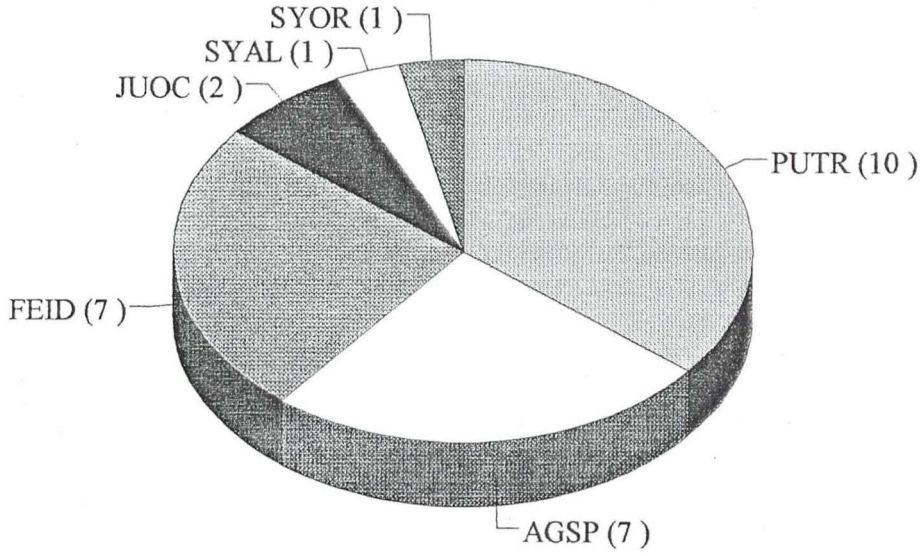


FIG. 11. WHITEBARK PINE HABITAT TYPES
(N=26 Stands)

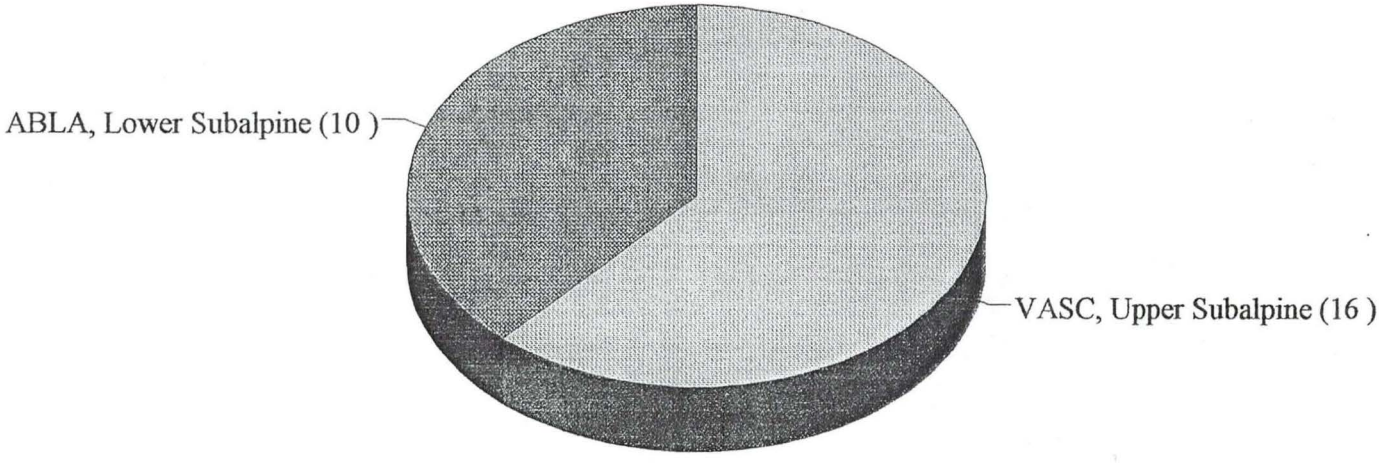


FIG. 12. STAND AGE STRUCTURE

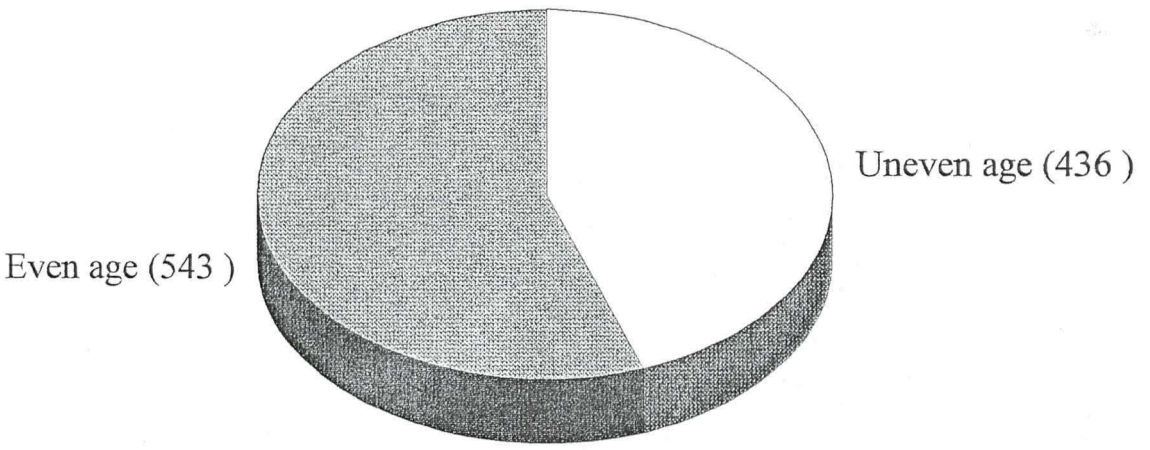


FIG. 13. NUMBER OF STAND SERAL AGE CLASSES

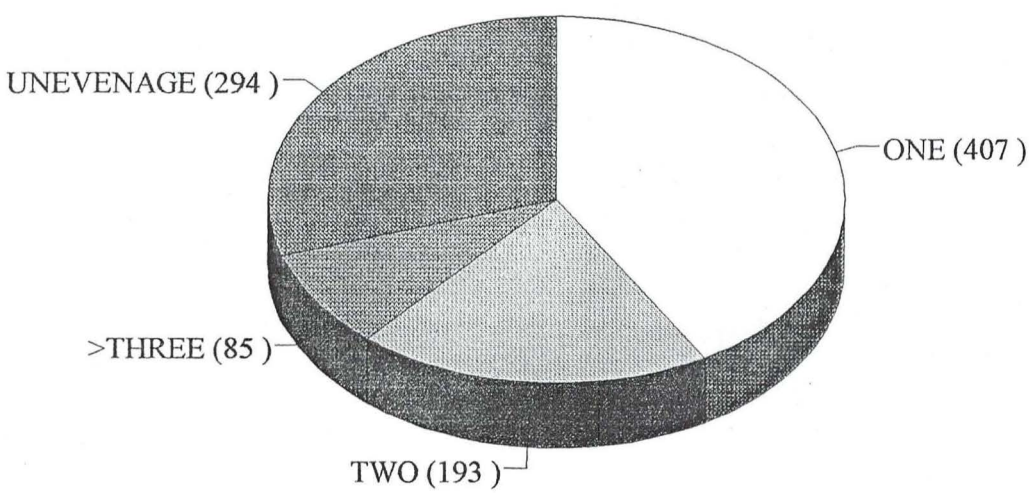


FIG. 14. STAND OVERSTORY STRUCTURE

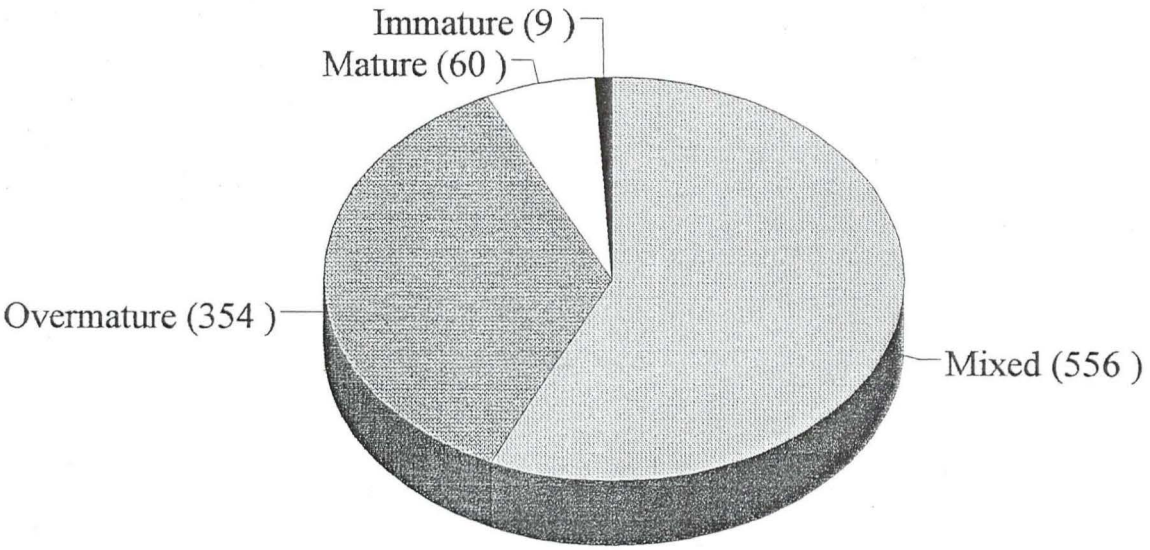


FIG. 15. STAND TOPOGRAPHY

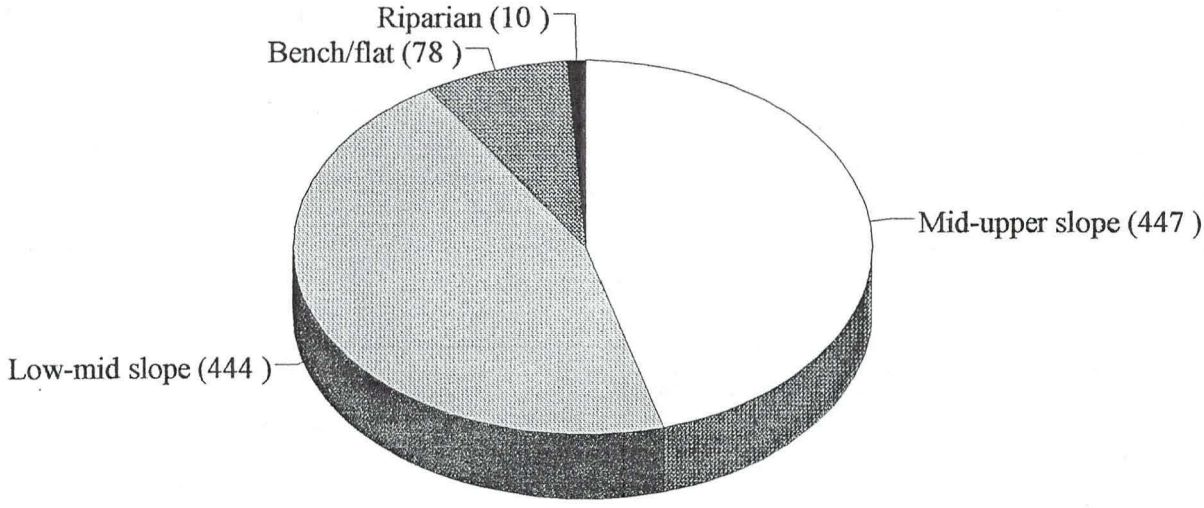


FIG. 16. LAND DISSECTION

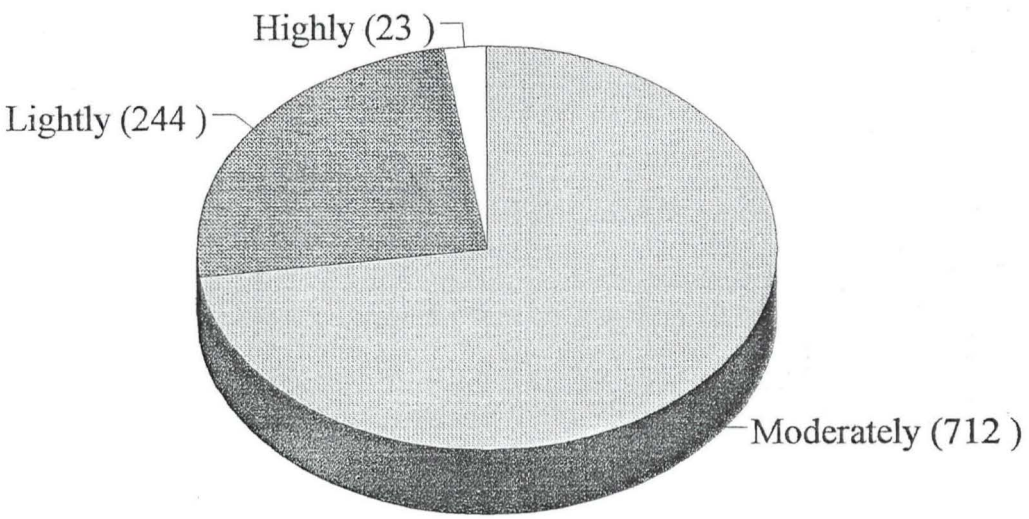


FIG. 17. STAND ASPECT

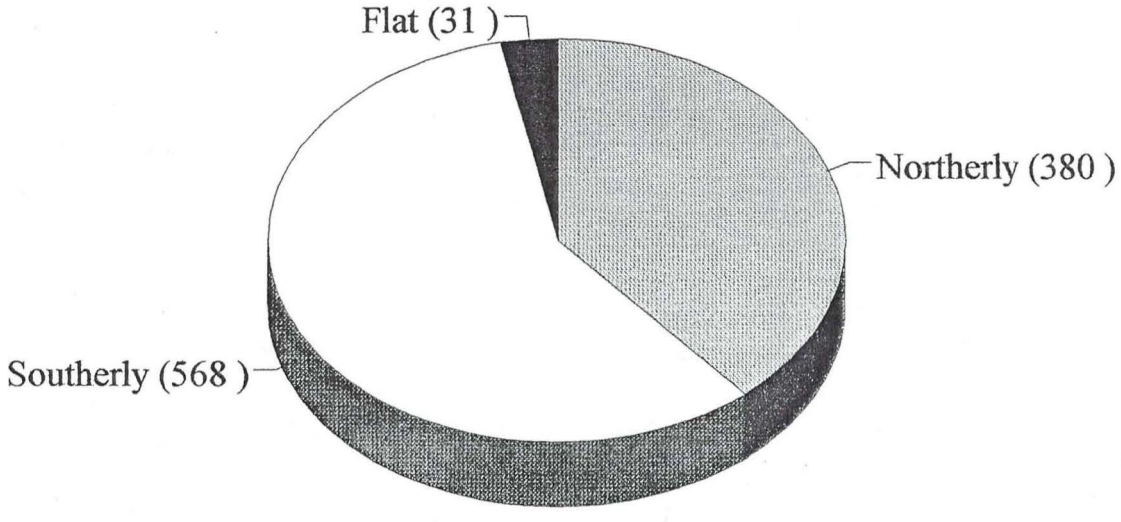


FIG. 18. STAND SLOPE

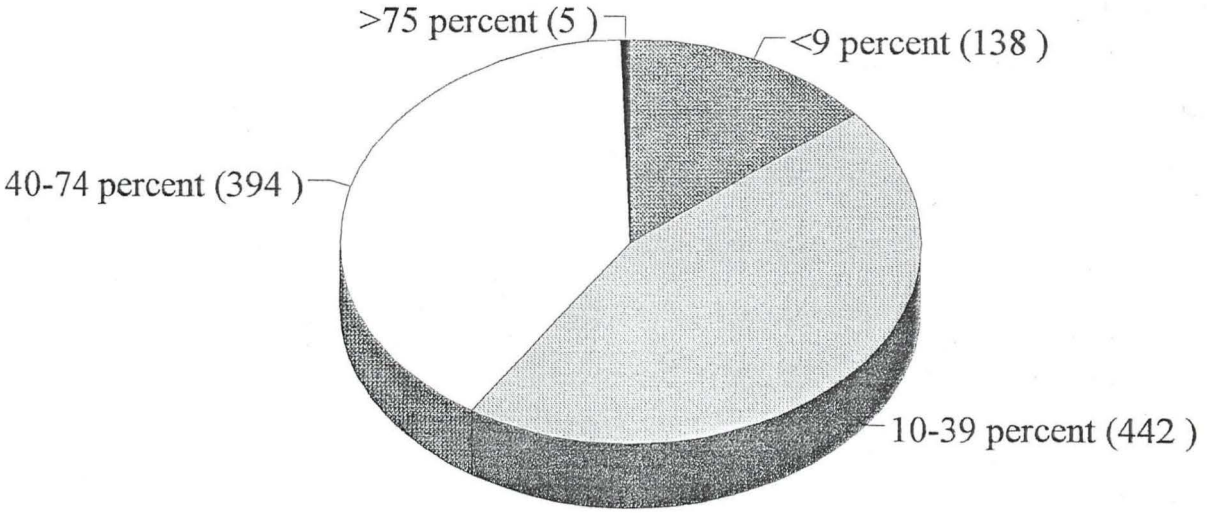


FIG. 19. STAND MAXIMUM ELEVATION RANGE

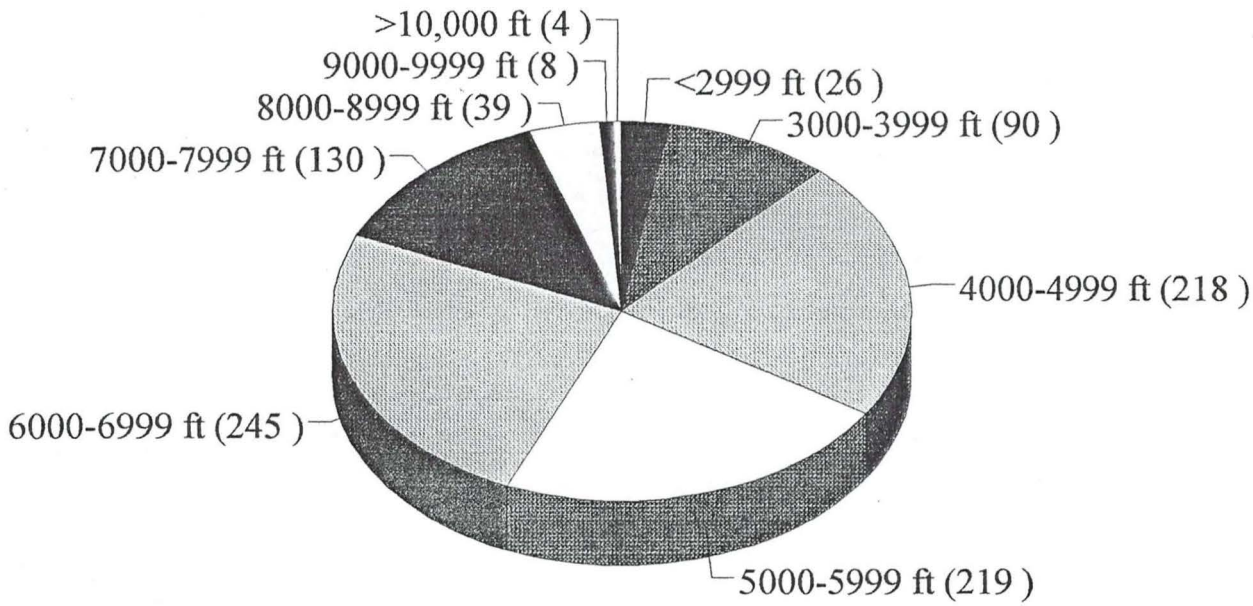


FIG. 20. STAND MEAN ANNUAL PRECIPITATION

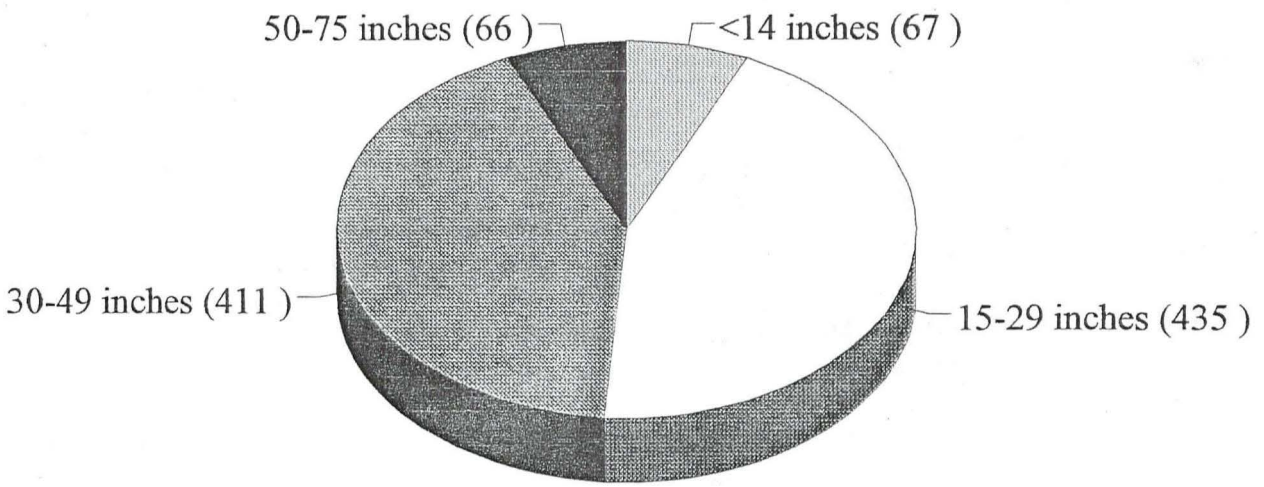


FIG. 21. FIRE SEVERITY CLASS

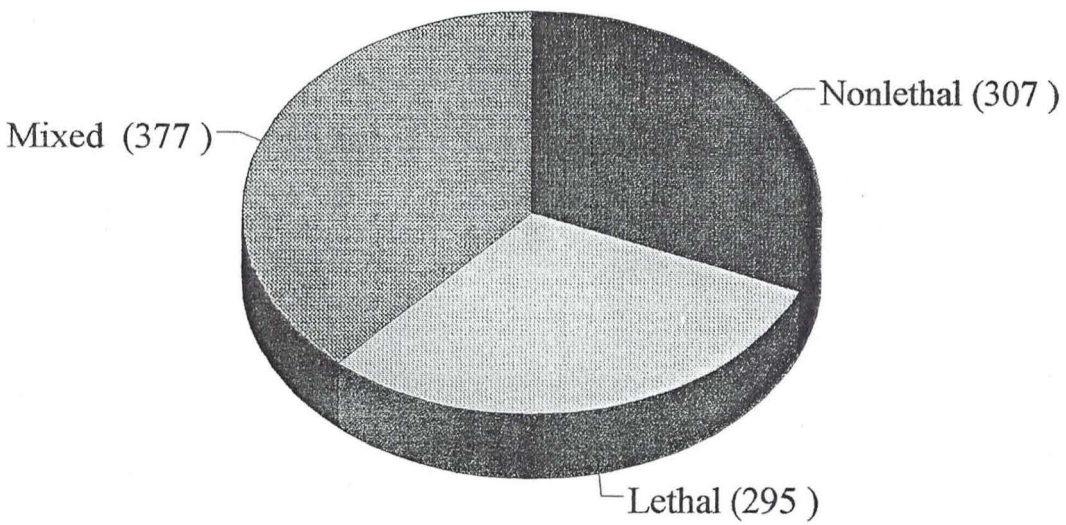


FIG. 22. STAND FIRE FREQUENCY (MFI)

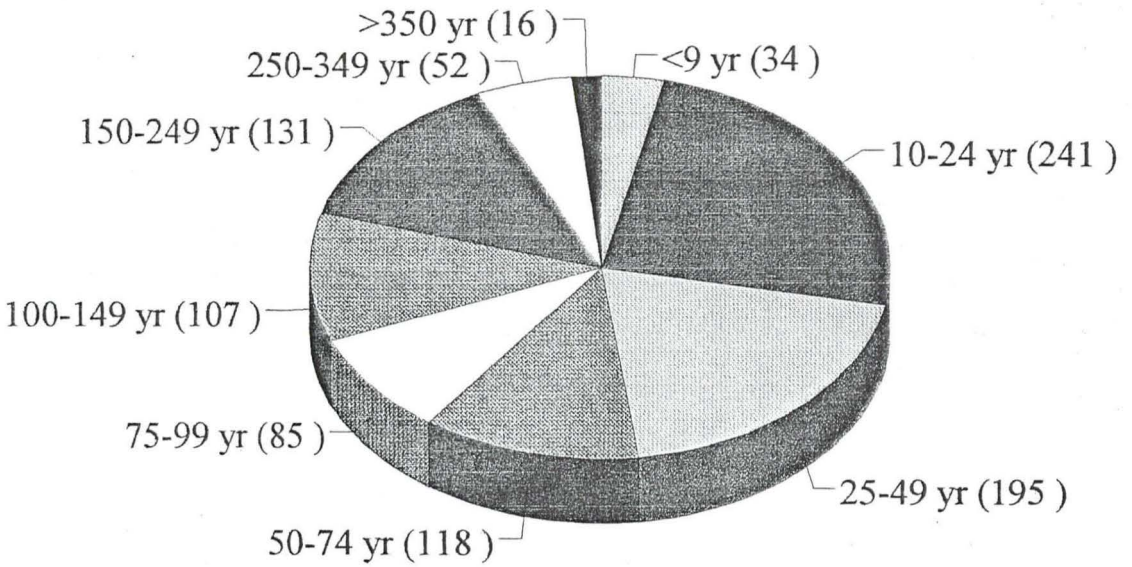
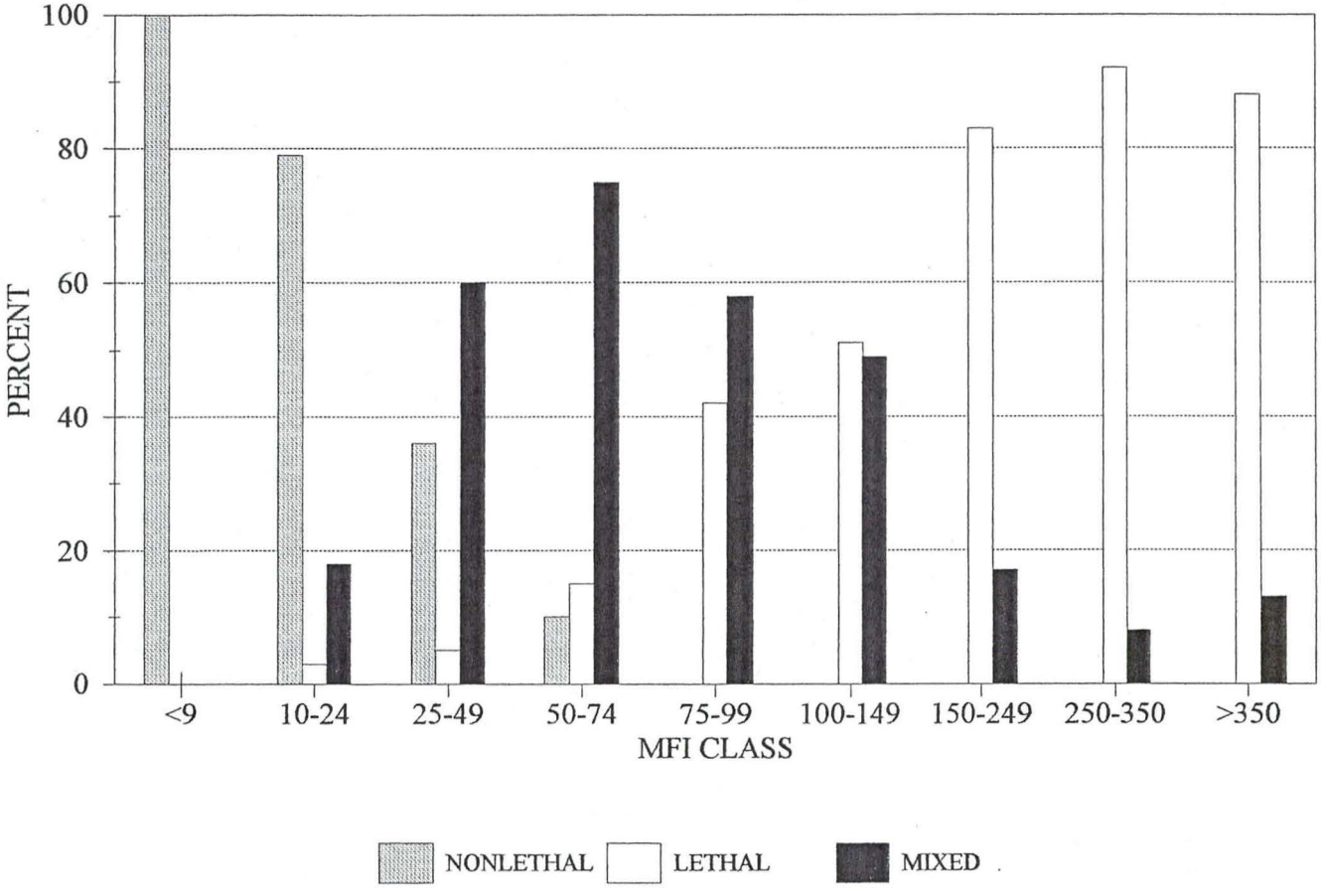


FIG. 23. FIRE SEVERITY BY FREQUENCY CLASS



APPENDIXES

A. Data form (with codes list) for fire regimes database.

B: Database Fire Regimes References.

1. Bibliography.
2. Numerically Ordered References.
3. References by SAF cover type.

C. Miscellaneous Habitat Types not cited in Figures 6-11 (N=88 stands).

APPENDIX A. Fire Regimes data form.

FIRE REGIMES DATA SHEET

(FOR AREADATA.DBF)

REFNUM:_____ AUTHOR/DATE:_____

SITE NAME:_____

PAGE:_____ REGION:_____ STATE:_____ LAT:_____ LONG:_____

AREA SURFACE FORM (A=smooth plain B=irregular plain C=rough plain D=plateau E=hills/narrow valleys F=open hills G=mtns./narrow valleys H= mtns./broad valleys I=plateau-like mts. J=plains with mts.):_____

ELEV. (ft.) MIN: _____ MAX:_____

LAND DISSECTION (A=highly B=moderately C=lightly) _____ MFI:_____

FIRE SEVERITY (A=non-lethal B=lethal C=mixed severity) _____

MEAN ANN. PCP:_____ NEAREST STN:_____

(FOR STANDS.DBF)

PAGE:_____

FOREST COVER TYPE (210=Interior Douglas fir 237=ponderosa pine 212=western larch 213=grand fir 211=white fir 218=lodgepole pine 217=aspen 206= spruce/subalpine fir 208=whitebark pine): _____

HABITAT:_____ TYPE:_____ (REF:_____)

OVERSTORY (A=immature B=mature C=overmature D=mixed) _____

AGE STRUCTURE (A=even age B=uneven age):_____

TOPOGRAPHIC POSITION (A=low to mid slope B=mid-upper slope C=bench/flat D=riparian) _____

NO. AGE CLASSES (0=uneven age stand) _____

SLOPE (A=flat to 10% B=10-40% C=40-75% D=>75%) _____

ASPECT (N=northerly S=southerly F=flat) _____

APPENDIX B-1. FIRE REGIMES BIBLIOGRAPHY

(Note: For data location purposes, original draft reports are cited in place of any subsequent less-detailed publications. Applicable dBASE files: "REGIMES.dbf"; "AREADATA.dbf"; "STANDS.dbf")

DBASE REF. NO.	
72	Anon. 1992. (Due to possible legal concerns, the author of this study in west-central Washington requested anonymity).
77	Antos, J. A. 1977. Grand fir (*Abies grandis* [Dougl.] Forbes) forests of the Swan Valley, Montana. M.A. thesis, Univ. Mont., Missoula. 220 p.
3	Arno, S. F. 1976. The historical role of fire on the Bitterroot National Forest. USDA For. Serv. Res. Pap. INT-187, Intermt. For. Range Exper. Sta., Ogden UT. 29 p.
52	___. 1981a. Fire history in the vicinity of Sheep Mountain Bog, Lolo National Forest. Unpub. Rept. on file at USDA For. Serv. Intermt. Exper. Sta., Intermt. Fire Sci. Lab., Missoula MT. 4 p.
31	___. 1981b. Fire history on the Fontenelle Creek aspen study site. Unpub. rept. on file at USDA For. Serv. Intermt. Exper. Sta., Intermt. Fire Sci. Lab., Missoula MT. 5 p.
51	___. 1985. Fire history in the vicinity of Mary's Frog Pond, Lolo National Forest. Unpub. rept. on file at USDA For. Serv. Intermt. Exper. Sta., Intermt. Fire Sci. Lab., Missoula MT. 2 p.
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29 Bakeman, M. E. 1983. The genesis of Mollisols under Douglas-fir. M.S. thesis, Univ. Mont., Missoula. 82 p.

6 Barrett, S. W. 1981. Relationship of Indian-caused fires to the ecology of western Montana forests. M.S. thesis, Univ. Mont., Missoula. 198 p.

16 ___. 1982. Fire's influence on ecosystems of the Clearwater National Forest: Cook Mountain fire history inventory. Unpub. final rept. on file at USDA For. Serv. Clearwater N. F., Orofino ID. 42 p.

4 ___. 1983. Fire history of Glacier National Park: North Fork Flathead River Drainage. Final Rept. Suppl. 22-C-2-INT-20 for USDA For. Serv. Intermt. For. Range Exper. Sta., Northern Forest Fire Lab., Missoula MT. 69 p.

1 ___. 1984a. Fire history of the River of No Return Wilderness: River Breaks Zone. Final Rept. Suppl. 22-C-2-INT-27-CA for USDA For. Serv. Intermt. For. Exper. Sta., Intermt. Fire Sci. Lab., Missoula MT. 40 p.

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APPENDIX B-2. FIRE REGIMES REFERENCES (Numerically Ordered)

DBASE REF NO. (Refer to Bibliography for full citations):

1=Barrett (1984a) 2=Sneck (1977) 3=Arno (1976) 4=Barrett (1983)
5=Barrett (1986a) 6=Barrett (1981) 7=Buck (1973) 8=Dorey (1979)
9=Gruell et al. (1982) 10=Arno & Davis (1980) 11=Romme (1980)
12=Loope & Gruell (1976) 13=Houston (1973) 14=Tande (1977) 15=Hawkes (1979)
16=Barrett (1982) 17=Means (1980) 18=Johnson & Smathers (1976)
19=Gruell et al. (1985) 20=Steele et al. (1986) 21=Barrett (1988b)
22=Gabriel (1976) 23=Barrett (1990) 24=Marshall (1928) 25=Arno & Gruell (1986)

26=Freedman & Habeck (1985) 27=McNeil (1975) 28=Soeriaatmadja (1966)
29=Bakeman (1983) 30=Arno & Gruell (1983) 31=Arno (1981b) 32=Pierce (1982)
33=Hall (1976) 34=Weaver (1961) 35=Weaver (1959) 36=Day (1972)
37=Strang & Parmenter (1980) 38=Rummel (1951) 39=Woodard (1977)
40=Ziegler (1977) 41=Barrett (1988a) 42=Arno & Carlson (1982) 43=Barrett (1991)
44=Barrett (1992a) 45=Habeck (1985) 46=Finch (1983) 47=Bork (1985)
48=Barrett (1985) 49=Barrett (1986b) 50=Barrett (1987)

51=Arno (1985) 52=Arno (1981a) 53=Arno et al. (1992) 54=Arno & Scott (1994)
55=Keane et al. (1994) 56=Melrose (1923) 57=Low (1988) 58=Cartwright (1983)
59=Taylor (1983) 60=Johnson & Fryer (1987) 61=Masters (1989) 62=White (1985)
63=Barrett (1994c) 64=Losensky (1992) 65=Losensky (1989) 66=Losensky (1987)
67=Barrett (1984b) 68=McCune (1983) 69=Barrett (1993a) 70=Barrett (1993b)
71=Makela (1990) 72=Anon. (1992) 73=Barrett (1992b) 74=Habeck (1992a)
75=Habeck (1992b)

76=Tymstra (1991) 77=Antos (1977) 78=Fahnestock (1976) 79=Morgan & Bunting(1990)
80=Barrett (1994a) 81=Barrett (1994b) 82=Maruoka (1994) 83=Bork (1984)
84=Burkhardt & Tisdale (1976) 85=Young & Evans (1981)
86=Wischnofske & Anderson (1983) 87=Losensky (1993a) 88=Losensky (1993b)
89=Losensky (1993c) 90=Losensky (1993d) 91=Agee (1991)
92=Zack & Morgan (1994) 93=Dickman & Cook (1989) 94=Taylor (1993)
95=Losensky (1993e) 96=Losensky (1993f) 97=Losensky (1993g)
98=Barrett (1994d) 99=Habeck (1994) 100=Arno (1994)

101=Pierce (1995a) 102=Pierce (1995b) 103=Pierce (1995c) 104=Pierce (1995d)

105=Pierce (1995e) 106=Pierce (1995f) 107=Pierce (1995g) 108=Lehman (1995)

APPENDIX B-3. FIRE REGIMES REFERENCES BY SAF COVER TYPE

SAF No.	Cover Type[2]	Reference No. (see Appendixes B-1, B-2)
237	PP	1, 3, 6, 7, 8, 9, 18, 19, 20, 21, 23, 26, 27, 28, 33, 34, 35, 38, 42, 43, 45, 46, 47, 48, 50, 54, 56, 57, 58, 65, 66, 67, 71, 72, 75, 80, 81, 82, 86, 87, 92, 99, 105
218	LP	2, 3, 4, 5, 11, 12, 13, 14, 15, 16, 22, 23, 26, 27, 31, 32, 36, 39, 40, 41, 44, 46, 49, 50, 51, 52, 53, 59, 60, 61, 62, 63, 64, 69, 70, 71, 72, 76, 78, 81, 83, 87, 88, 89, 90, 92, 93, 95, 97, 98, 99, 101, 102, 104
210	DF	1, 3, 12, 13, 14, 17, 22, 23, 25, 28, 29, 30, 31, 32, 37, 44, 46, 48, 50, 62, 63, 72, 74, 75, 76, 80, 82, 86, 87, 88, 89, 90, 91, 92, 95, 96, 97, 98, 101, 102, 103, 104, 107, 108
212	WL	2, 3, 4, 5, 10, 16, 21, 24, 26, 41, 43, 45, 49, 50, 51, 52, 67, 72, 73, 75, 77, 81, 92, 99, 100
208	WB	3, 4, 11, 12, 14, 22, 23, 44, 52, 55, 63, 70, 76, 79, 88, 92
206	S-F	2, 3, 10, 12, 15, 22, 23, 29, 36, 52, 60, 62, 63, 76, 78, 92, 98, 107
227	C-H[3]	10, 16, 23, 24, 43, 49, 72, 76, 77, 80, 86, 92, 106, 107
217	ASP	12, 14, 29, 31, 32, 44, 62, 70, 76, 98
213	GF	68, 72, 77, 80, 86, 106
215	WP	10, 24, 92
219	LIMB	101, 103, 104, 108
238	WJ	18, 84, 85
205	MH	80, 92, 93
211	WF	27
207	RF	94, 96

[2] Codes not in Fig. 4: GF (grand fir), WP (white pine), LIM (limber pine), WJ (western juniper, MH (mountain hemlock), WF (white fir), RF (red fir).

[3] Group includes SAF #224, 228 (i.e., western hemlock, western redcedar).

APPENDIX C. Miscellaneous Habitat Types not cited in Figs. 6-11 (N=88 stands)

SERIES	ASSOCIATION	NO. STANDS
PICO	PUTR	4
	VASC	2
LALY	ABLA	8
	PHEM (*Phyllodoce empetriformis*)	2
ABCO	ARNE	1
	CEVE (*Ceanothus velutinus*)	10
	CHUM	2
	SYAL	1
ABMA	ARNE	2
	CHUM	1
TSHE	ACTR	1
	ASCA	6
	BENE	1
	CLUN	3
	GYDR	1
	LIBO	1
	PSME	1
TSME	CLUN	1
	STAM	1
	VASC	5
	XETE	1
PIEN	CAGE	1
	CLUN	5
	LIBO	1
	RIMO	1

	VACA	3
PIGL	VACA	7
PIFL	AGSP	2
	FEID	4
	FESC	1
JUOC	ARAR (*Artemisia arbuscula*)	2
	ARTR (*Artemisia tridentata*)	4
LIDE	CHUM	1
	WHMO (*Whipplea modesta*)	1